CHAPTER 4

COMPARISON OF OM-OFDM AND CE-OFDM

4.1 INTRODUCTION

In this thesis, an offset modulation method has been proposed to control the PAPR of an OFDM transmission. The proposed OM-OFDM method may appear to be similar if not identical to phase modulation of an OFDM transmission, which is well known [82–90]. In this chapter the differences between an OM-OFDM and CE-OFDM methods are evaluated and the benefits of the OM-OFDM method are presented.

4.2 STRUCTURAL COMPARISON

Consider the discrete complex output of an N-point inverse fast Fourier transformed OFDM signal, given by

$$m_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j\frac{2\pi nk}{N}}, \qquad n = 0, 1, ..., N-1. \tag{4.1}$$

In Eq (4.1), X_k represents the complex signal output $(a_k + jb_k)$ of the IFFT. This signal may be modulated using the method which follows

$$\Phi_{1n} = \frac{\Re(m_n)}{\varsigma} \quad \text{and} \quad \Phi_{2n} = \frac{\Im(m_n)}{\varsigma}. \tag{4.2}$$

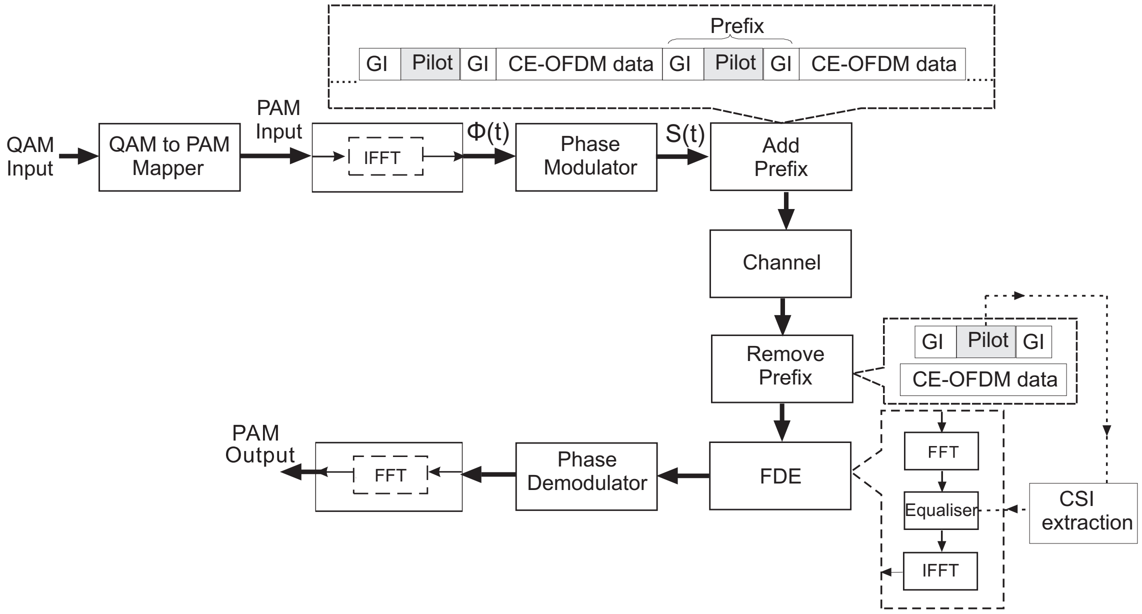
In Eq (4.2), m_n denotes the discrete complex OFDM signal, ς refers to a constant division term, $\Re$ and $\Im$ refer to the real and imaginary parts of an OFDM signal respectively. In addition, Φ_{1n} and Φ_{2n} represent the equivalent discrete real and imaginary OFDM phase mapping. These Φ_{1n} and Φ_{2n} terms are passed through a DAC and may now be combined into a co-sinusoid, given by

$$s(t) = \cos(2\pi f_c t + \Phi_1(t) + \Psi_{os}) - \cos(2\pi f_c t + \Phi_2(t)) \tag{4.3}$$

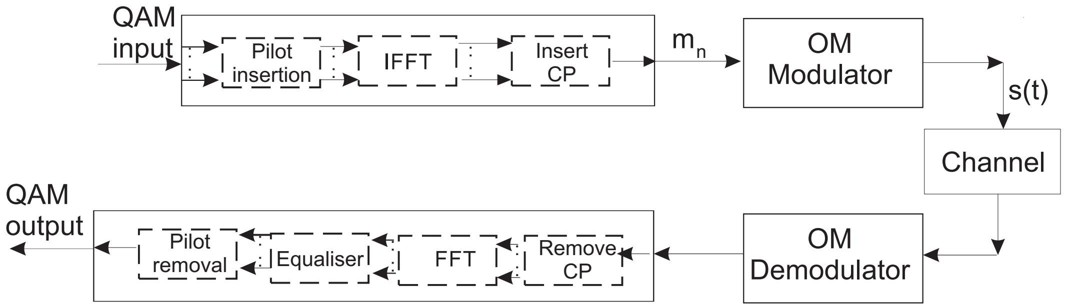
here, Ψ_{os} refers to an offset term, $\Phi_1(t)$ and $\Phi_2(t)$ represent the equivalent real and imaginary OFDM phase mapping. The Ψ_{os} and ς terms ensure that the receiver can successfully detect the originally transmitted signal. The proposed offset modulation method may appear to be similar, if not identical, to CE-OFDM. A CE-OFDM transmission is ideally suited for constellations without imaginary components (e.g. BPSK). In cases where imaginary components exist (e.g. such as in 16-QAM), as depicted in Fig. 4.1(a), this constellation is uniquely mapped onto a constellation without imaginary components (e.g. 16-QAM to 16-PAM mapping). This mapping process results in a severe BER degradation. After the mapping process, depicted in Fig. 4.1(a), an IFFT is performed on the mapped signal. The resultant OFDM signal, denoted by $\phi(t)$ in Fig. 4.1(a), is phase modulated as shown below

$$S(t) \quad = \quad A_c \cos(2\pi f_c t + 2\pi h \phi(t)). \tag{4.4}$$

In Eq (4.4), A_c is the signal amplitude, f_c is the carrier frequency and h denotes the modulation index. On the contrary, an OM-OFDM transmission modulates a constellation containing both real and imaginary components without a mapping process. The OM-OFDM transmission may appear to be a phase modulated signal, therefore losing its attractive OFDM properties. However, the OM-OFDM system's transmitter receiver structure (Fig. 4.1(b)) maintains the fundamental OFDM building blocks. The OM-OFDM equalisation process is identical to that employed in OFDM. Channel state information is extracted from the pilot symbols and used during the equalisation process to mitigate the effects of fading. Thus, OM-OFDM still maintains the ease of equalisation, whereas the CE-OFDM transmission re-



(a) CE-OFDM structure [100]



(b) OM-OFDM structure

Figure 4.1: A CE-OFDM (a) and OM-OFDM (b) transmitter-receiver structure comparison.

quires a more complex equalisation process. During a CE-OFDM transmission, as depicted in Fig. 4.1(a), a frequency-domain equaliser (FDE) is used to mitigate the effects of a channel. The FDE extracts CSI from the prefix (pilot and guard intervals (GI)), which are inserted between successive CE-OFDM blocks. During the FDE process either a zero-forcing or minimum mean-squared error equaliser can be used. The CE-OFDM equalisation process requires additional overhead (pilot and GI) and an increase in computational complexity when compared to an OM-OFDM transmission. A comparison between Fig. 4.1(b) and Fig. 4.1(a) demonstrates the structural difference between an OM-OFDM and CE-OFDM transmission, in particular the placement of the equaliser. The only similarity that OM-OFDM and CE-OFDM share is that both methods involve a form of phase modulation, other than that the two methods are significantly different.

4.3 BANDWIDTH COMPARISON

The bandwidth occupancy for $N = 1$, of an OM-OFDM transmission can be written as (Eq (3.15))

$$\begin{aligned} u_n \; = \; & \sum_{y=0}^{2x} \left| \sum_{z=0}^{2x-y} 2\sin\left(\frac{\pi(2x-2z-y)\pm 2\Psi_{os}}{4}\right)\cdot J_{|-x+z|}(\beta_1)\left(\frac{|-x+z+\frac{1}{2}|}{-x+z+\frac{1}{2}}\right)^{|-x+z|}\cdot \right. \\ & \left. J_{|x-y-z|}(\beta_2)\left(\frac{|x-y-z+\frac{1}{2}|}{x-y-z+\frac{1}{2}}\right)^{|x-y-z|}\cdot\sin\left(2\pi(f_c+yf_d)+\frac{2\Psi_{os}\pm y\pi}{4}\right)\right|. \end{aligned} \quad (4.5)$$

Then by inspection of Eq (4.5), Fig. 4.2 depicts the frequency spectrum of an OM-OFDM and CE-OFDM transmission, where A_c refers to the envelope of the phase modulated signal. The frequency spectrum of an OM-OFDM transmission is different from that of a conventional phase modulated signal. The squaring of the Bessel functions limits the bandwidth occupancy of an OM-OFDM signal. This indicates that the OM-OFDM transmission is spectrally more efficient than a CE-OFDM transmission. In order to further validate this mathematical analysis, in Fig. 4.3 the bandwidth occupancies of an OM-OFDM, OFDM and CE-OFDM transmission are compared. The bandwidth occupancies of an OM-OFDM,

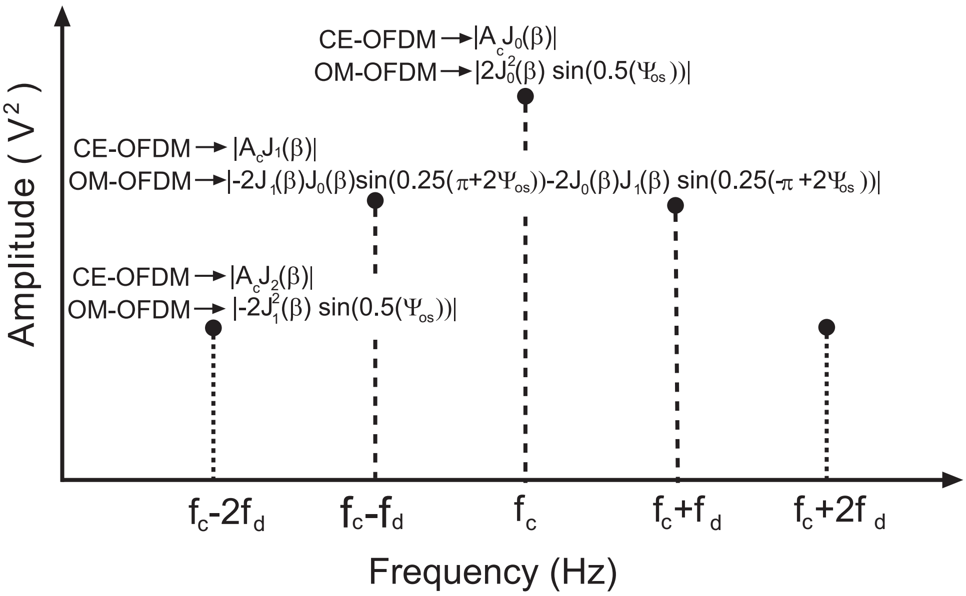
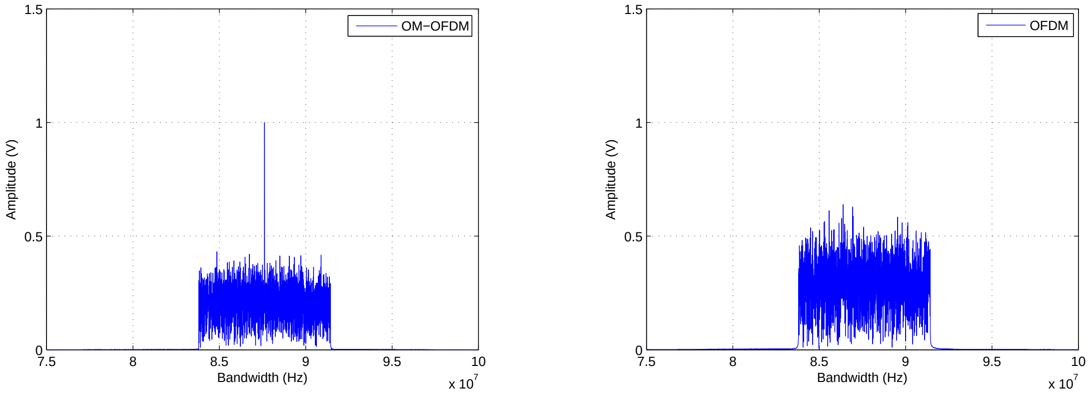
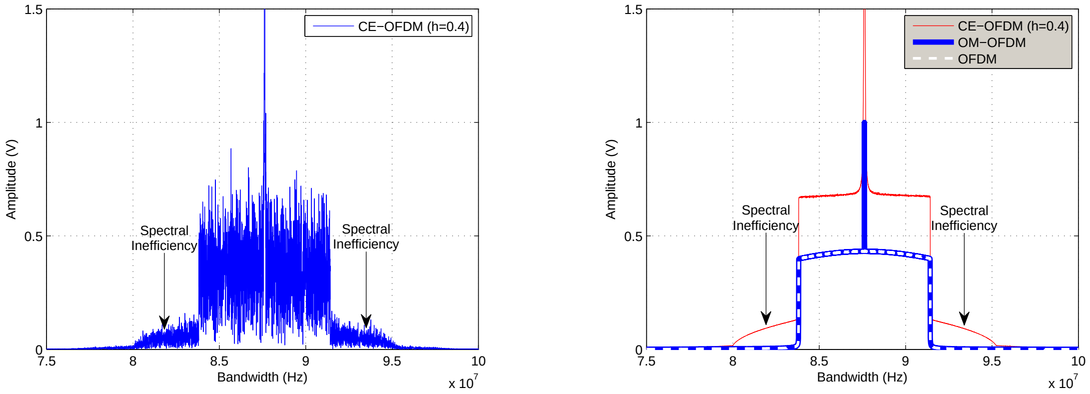


Figure 4.2: A CE-OFDM and OM-OFDM theoretical derived frequency spectrum comparison.



(a) Normalised OM-OFDM bandwidth occupancy

(b) OFDM bandwidth occupancy



(c) CE-OFDM bandwidth occupancy

(d) Averaged OM-OFDM, OFDM and CE-OFDM bandwidth occupancy

Figure 4.3: An OM-OFDM, OFDM and CE-OFDM bandwidth comparison.

OFDM and CE-OFDM transmission are presented in Fig. 4.3(a), Fig. 4.3(b) and Fig. 4.3(c), respectively. Both the OM-OFDM (Fig. 4.3(a)) and OFDM (Fig. 4.3(b)) methods appear to be spectrally efficient, whereas in Fig. 4.3(c), for the CE-OFDM method, spectral inefficiencies are noticed. Furthermore, in Fig. 4.3(d), the average bandwidth occupancy of the OM-OFDM, OFDM and CE-OFDM transmissions are compared. This OM-OFDM and OFDM comparison further highlights their spectral efficiency and the CE-OFDM method depicts its spectral inefficiencies. The mathematical reasoning for this type of result has been discussed previously (Fig. 4.2).

In addition, by subtracting $2\gamma J_0(\beta)^2 \sin(2\pi f_c t - \frac{\Psi_{os}}{2}), \quad 0 \leq \gamma < 1$ (where γ is the dominant frequency component control factor) from the dominant frequency of an OM-OFDM transmission, the PAPR of such a transmission (Eq (4.3)) may be controlled in order to improve the BER characteristic. This is not the case in a CE-OFDM transmission, where the PAPR is fixed at a desirable 3 dB PAPR, but at the expense of a severe BER degradation. The BER characteristics of a CE-OFDM transmission may be improved by increasing the bandwidth occupancy (modulation index) of such a transmission. This involves frequency domain spreading of the signal. However, in certain instances spreading the CE-OFDM signal into a noise floor worsens the BER characteristics instead of improving them.

4.4 RESULTS AND DISCUSSION

In all the results which follow, the 2k mode of the DVB - T2 standard [95] was used to transmit OFDM, OM-OFDM and CE-OFDM (16-QAM Gray-coded) data through a 3-tap bad-urban frequency selective fading channel, the channel was obtained from [96]. Identical throughput and bandwidth occupancies were used to ensure a fair comparison between the various methods. The OM-OFDM method as well as the other methods, conforms to both the throughput and the spectrum mask properties imposed by the DVB-T2 standard. Perfect carrier and timing synchronisation is assumed. The parameters used for the OM-OFDM transmission are given in Table 4.1, and the modulation index of a CE-OFDM transmission is $2\pi h = 0.0628$.

Table 4.1: Parameters for a 16-QAM OM-OFDM system ($\alpha = 0.07408$)

PAPR	Ψ_{os}	ς	γ	φ
3 dB	1.7	$20000/4096$	1.00E-05	3.76E-03
4 dB	1.5	$10000/4096$	0.807	3.92E-02
5 dB	1.5	$10000/4096$	0.91	8.41E-02
6 dB	1.5	$10000/4096$	0.945	1.38E-01
7 dB	1.5	$10000/4096$	0.963	0.205
8 dB	1.5	$10000/4096$	0.973	0.280
9 dB	1.5	$10000/4096$	0.98	0.378
10 dB	1.5	$10000/4096$	0.985	0.505
11 dB	1.5	$10000/4096$	0.988	0.631
12 dB	1.5	$10000/4096$	1	1.0

4.4.1 Bit error rate performance analysis

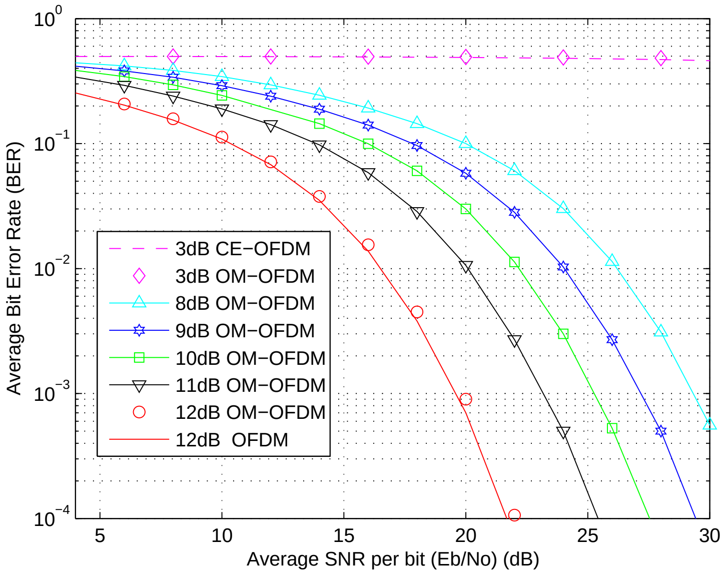


Figure 4.4: A BER comparison between an OM-OFDM, OFDM and a CE-OFDM transmission in a 3-tap bad-urban frequency selective fading channel.

The averaged PAPR of an OFDM transmission when using the DVB-T2 standard, according to simulations, is 12 dB. This PAPR is fixed for an OFDM transmission, whereas OM-OFDM allows the PAPR of the signal to be varied, while maintaining identical throughput and bandwidth occupancy as an OFDM transmission. Hence, from a direct BER comparison between OM-OFDM and OFDM, depicted in Fig. 4.4, it is noted that both methods offered similar BER characteristics at a PAPR of 12 dB. A further BER comparison between OM-OFDM and CE-OFDM, partially depicted in Fig. 4.4, indicates that for a similar PAPR (3 dB) both methods offered similar BER characteristics. At a BER of 10^{-4} the SNR of a CE-OFDM transmission is 68.85 dB. This indicates the extent of the severe BER degradation for a fixed PAPR of 3 dB.

4.4.2 Decision metric performance analysis

In order to facilitate a direct comparison between OFDM, OM-OFDM and CE-OFDM transmissions, the decision metric discussed in Section 3.7, together with a standard OTS AN10858 RF power amplifier, was employed. When using this decision metric, as depicted

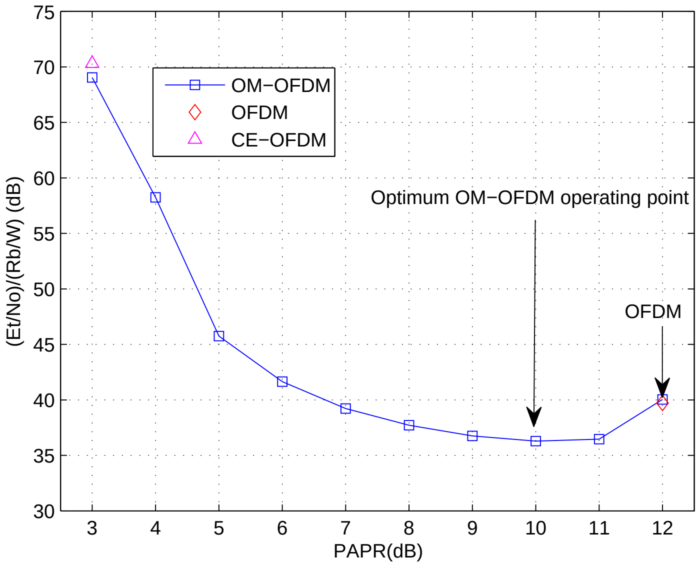


Figure 4.5: System performance at a BER of 10^{-4} for an AN10858 amplifier.

in Fig. 4.5, the optimum operating point for an OM-OFDM transmission is at a PAPR of 10 dB (where a minimum decision metric occurs). At this optimum operating point, depicted in Fig. 4.5, the OM-OFDM transmission is shown to offer a net power performance gain of 34 dB and 3.44 dB (at a BER of 10^{-4}) when compared to CE-OFDM and traditional OFDM transmissions, respectively. Furthermore, the decision metric suggests that the OM-OFDM method's average PAPR value may be lowered to 8 dB (thus a 4 dB average PAPR reduction when compared to the original OFDM transmission), while maintaining a performance improvement when compared to an OFDM transmission. A comparison between OM-OFDM and CE-OFDM indicates the significant power performance improvements offered by OM-OFDM.

This decision metric result might appear to be misleading, since at a BER of 10^{-4}, shown in Fig. 4.4, a 3.44 dB net gain is not expected. This 3.44 dB net power performance gain is attributed to the fact that there is an exponential relationship between PAPR (dB) and PAE (Fig. 2.9), instead of a linear relationship. Thus as the PAPR decreases, efficiency increases exponentially; this relationship is valid within a certain PAPR range. It is this association which leads to the 3.44 dB net power performance gain.

4.5 CONCLUSIONS

The proposed OM-OFDM method appears to be similar to a well-known CE-OFDM transmission. In this chapter, the significant differences between an OM-OFDM and CE-OFDM method are demonstrated. Thereafter, by using a decision metric, OM-OFDM is shown to offer a phenomenal 34 dB improvement when compared to a CE-OFDM transmission and a 3.44 dB (54.7%) net performance gain (at a BER of 10^{-4}) when compared to a traditional OFDM transmission for frequency selective fading channel conditions.

CHAPTER 5

OFFSET MODULATION RESULTS AND DISCUSSION

5.1 INTRODUCTION

In this chapter, in order to demonstrate the benefits of OM-OFDM, the proposed OM-OFDM method is compared to an OFDM transmission, as well as existing PAPR reduction methods. A 64-QAM Gray-coded 8k mode of the DVB-T2 standard [95] was used to compare OFDM, active constellation extended OFDM, tone reserved OFDM, OM-OFDM and classically clipped OFDM transmissions.

The clipping method was chosen, since to the best of the author's knowledge this method, in conjunction with the OM-OFDM method, are the only methods currently in the PAPR field which allow for the accurate control of the PAPR of an OFDM transmission. The ACE and TR methods were selected since the DVB-T2 standard has recommended that these methods be used to reduce the PAPR of an OFDM transmission.

5.2 METHODOLOGY

When classically clipping a signal, both in-band and out-of-band distortions are introduced. In order to minimise the in-band distortion, the clipped OFDM signal was oversampled by a factor of 4. To limit the out-of-band distortion, the clipped OFDM signal was filtered before transmission with an 7th order Butterworth band-pass filter with a 9 dB ripple in the pass-band and a 42 dB stop attenuation.

The ACE method made use of the projection onto convex sets (POCS) [69, 73] approach. This iterative filtering and clipping ACE process involves using an oversampled signal (oversampled by a factor of 4), which is clipped with a clipping threshold of 7.8 dB and thereafter filtered with a 14th order Butterworth band-pass filter with a 9 dB ripple in the pass-band and a 42 dB stop attenuation.

The outer constellation points of this clipped and filtered signal, which lie within a certain region that does not affect the BER, are left unaltered, hence the constellation is said to be extended. The remaining constellation points are returned to their original position (before the clipping and filtering process). The outer constellation points have a maximum constellation extension limit (L) and the limit for this particular case is $L = 1.4$ (as recommended in the DVB-T2 standard). This iterative POCS approach was terminated after 30 iterations, since this proved to be a convergence point. The clipping threshold and filter parameters were determined after an exhaustive search.

Similarly, the POCS approach was used in the TR method. Each sub-carrier in the TR method is limited to 10 times the average power of the data carriers (as recommended in the DVB-T2 standard). The TR signal is oversampled by a factor of 4, with a clipping threshold of 7.8 dB. This iterative POCS approach, used for the TR method, was terminated after 60 iterations, since this proved to be a convergence point.

Furthermore, in all the BER results which follow, a 64-QAM Gray-coded 8k mode of the DVB-T2 standard was used to transmit OM-OFDM, OFDM and clipped OFDM data through a 5-tap typical-urban frequency selective fading channel. For an OM-OFDM, OFDM and clipped OFDM transmission, CSI is extracted from the pilot symbols and used during the equalisation process to mitigate the effects of fading. The pilot symbol placement, as well as tone reserved sub-carrier (used in TR), can be found in the DVB-T2 standard. Similarly the 5-tap typical-urban area model was obtained from Patzold [96] (which originates from the COST 207 models). Identical throughput and bandwidth occupancies were used to ensure a fair comparison between the various methods. The OM-OFDM method as well as the other methods, conforms to both the throughput and the spectrum mask properties imposed by the DVB-T2 standard. Perfect carrier and timing synchronisation is assumed. In Table 5.1, the parameters used for the OM-OFDM transmission are presented.

Table 5.1: Parameters for an 64-QAM OM-OFDM system ($\alpha = 0.27$)

PAPR	Ψ_{os}	ς	γ	φ
7 dB	1.596	44000/16384	0.86	0.2
8 dB	1.596	44000/16384	0.9	0.251
9 dB	1.596	44000/16384	0.925	0.34
10 dB	1.596	44000/16384	0.943	0.44
11 dB	1.596	44000/16384	0.962	0.53
12 dB	1.596	44000/16384	0.97	0.67
13 dB	1.596	44000/16384	1	1

5.3 BIT ERROR RATE PERFORMANCE ANALYSIS

OM-OFDM, OFDM and clipped OFDM data were sent through a 5-tap typical-urban area by using the parameters previously mentioned. The averaged PAPR of an OFDM transmission when using the 8k mode of the DVB-T2 standard, according to simulations, is 13 dB. This PAPR value has also been verified independently by [98]. This PAPR is fixed for an OFDM transmission and may only be changed, as discussed in Section 2.8, by adopting one or some of the PAPR reduction methods. For the same DVB-T2 standard OM-OFDM allows the PAPR of the signal to be varied, while maintaining identical throughput and bandwidth occupancy as an OFDM transmission.

A direct BER comparison, as shown in Fig. 5.1, between OFDM and OM-OFDM can be made when both methods offer the same PAPR (13 dB). From this OM-OFDM and

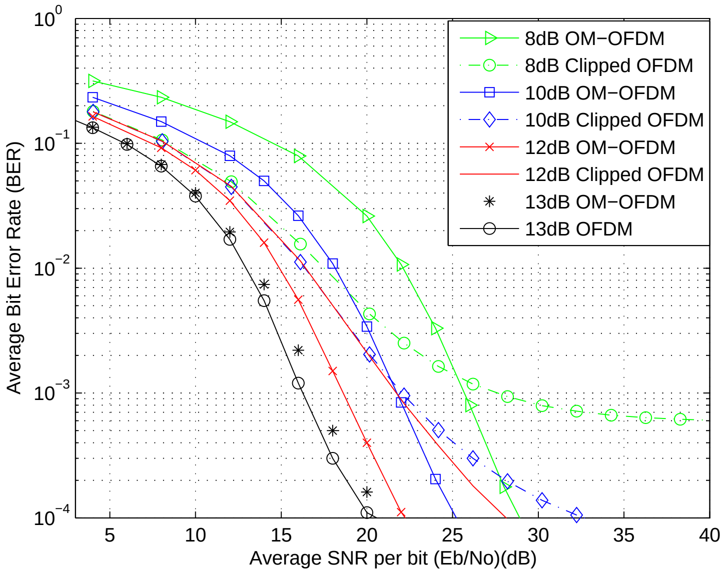


Figure 5.1: A 64-QAM constellation, BER comparison between an OM-OFDM, OFDM and a clipped OFDM transmission in a 5-tap typical-urban area.

OFDM comparison, it is noted that both methods offered similar BER characteristics at a PAPR of 13 dB. The OM-OFDM method, in addition, allows the designer to vary the PAPR until a desired BER is achieved. A further comparison between OM-OFDM and a clipped OFDM transmission shows that the clipped OFDM transmission reaches a BER plateau (PAPR $\leq$ 9 dB), whereas OM-OFDM does not result in a BER plateau for this case.

When a signal is clipped, information about the signal is permanently removed. Methods such as DAR clipping [28], as previously discussed, have been recommended to be used to reconstruct the clipped method, i.e. restore missing information about the signal. However this DAR method does not work well under frequency selective fading conditions. This permanent removal of information about the signal during clipping results in the BER plateau effect (PAPR $\leq$ 9 dB). A combination of the removal of information about the signal and the channel effects results in these subsequent clipping BER characteristics. OM-OFDM, on the other hand, does not remove information about the transmission, hence no BER plateau effect occurs. For the ACE and TR method the resultant fixed average PAPR is 12 dB and 12.7 dB, respectively. The BER performance of the ACE and TR methods is not presented, since it resembles that of an OFDM transmission.

5.4 DECISION METRIC PERFORMANCE ANALYSIS

In order to facilitate a direct comparison between OM-OFDM, OFDM, ACE, TR and a clipped OFDM transmission, the decision metric discussed in Section 3.7 was utilised. The decision metric employed a standard OTS FPD2000AS [101] RF power amplifier. A 10th degree polynomial was used to describe the PAE for this particular amplifier. In Fig. 5.2, the PAE, as well as the input-output characteristics of such an amplifier, are depicted. The results depicted in Fig. 5.3 were obtained when using the decision metric.

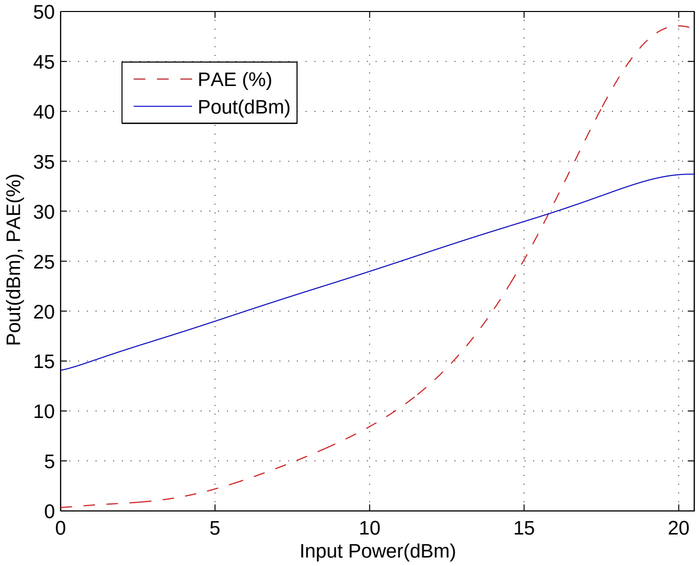


Figure 5.2: Power compression curves of an FPD2000AS amplifier [101].

When using this standard OTS power amplifier, as depicted in Fig. 5.3, the optimum operating point for an OM-OFDM transmission is at a PAPR of 10 dB (where a minimum decision metric occurs) and for the ACE and clipped OFDM transmission the optimum operating points are 12 dB. Similarly, the TR transmission has an optimum operating point at 12.7 dB.

At these optimum operating points OM-OFDM offers a net power performance gain of 1.2 dB (23.6%), 2 dB (36.8%), 2.2 dB (39.8%) and 4.1 dB (60.8%), at a BER of 10^{-4}, when compared to an ACE, TR, OFDM and clipped OFDM transmission respectively.

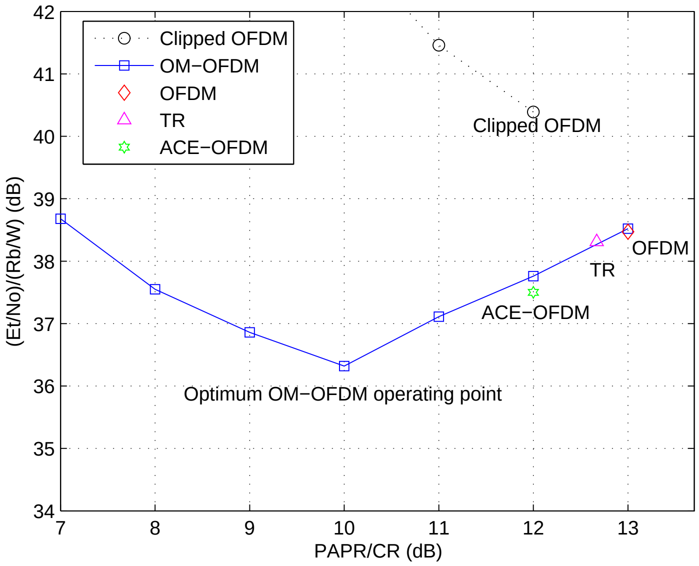


Figure 5.3: System performance for a 64-QAM constellation at a BER of 10^{-4} for a FPD2000AS RF power amplifier.

Hence, the OM-OFDM method offers a performance improvement when compared to an ACE and TR method, without the need for an iterative (30-60 iterations) process. Furthermore the decision metric suggests that the OM-OFDM method's PAPR value may be lowered to 8 dB (thus a 5 dB PAPR reduction when compared to the original OFDM transmission), while maintaining a performance improvement when compared to an ACE, TR, OFDM and clipped OFDM transmissions.

This decision metric result might appear to be misleading, since from Fig. 5.1 at a BER of 10^{-4}, a 2.2 dB net gain is not expected, as proposed by the decision metric. This 2.2 dB net power performance gain is attributed to the fact that the PAE curve of a typical amplifier is exponentially shaped, depicted in Fig. 5.2, instead of linear. Hence, there is an exponential relationship between PAPR (dB) and PAE, instead of a linear relationship. As the PAPR decreases, there is an exponential increase in efficiency; this relationship is valid within a certain PAPR range. It is this association which leads to the 2.2 dB net power performance gain.

In order to validate the results further, another standard OTS AN10858 [98] RF power amplifier, manufactured by a different supplier, was used. A 2nd degree polynomial was used to describe the PAE of this particular amplifier. Similar to the previous case for this

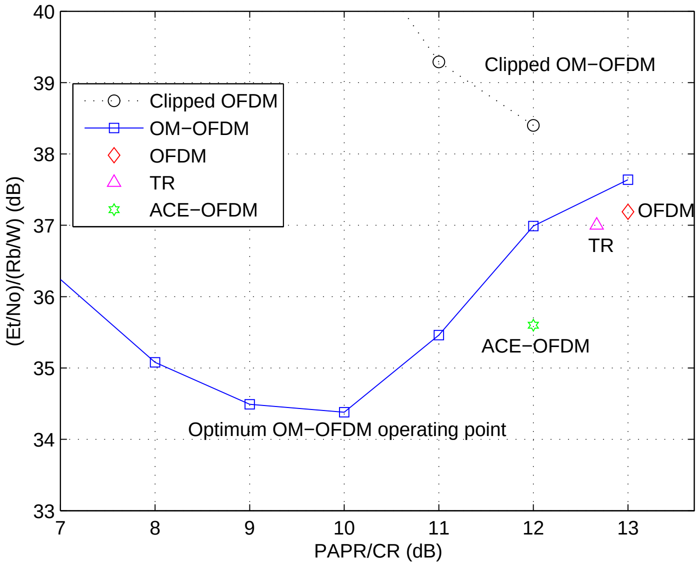


Figure 5.4: System performance for a 64-QAM constellation at a BER of 10^{-4} for a AN10858 RF power amplifier.

AN10858 standard OTS power amplifier, depicted in Fig. 5.4, at the optimum operating points OM-OFDM offers a net power performance gain of 1.2 dB (23.6%), 2.7 dB (45.3%), 2.8 dB (47.6%) and 4 dB (60.4%), at a BER of 10^{-4}, when compared to an ACE, TR, OFDM and clipped OFDM transmissions respectively. Hence, the OM-OFDM method again offers a performance improvement when compared to an ACE and TR method. Furthermore, the decision metric suggests that the OM-OFDM method's PAPR value may be lowered to 8 dB, while maintaining a performance improvement.

In Table 5.2, the decision metric improvements obtained when using OM-OFDM for the FPD2000AS and AN10858 RF power amplifiers are summarised. From these comparisons, it is noted that OM-OFDM offers a performance improvement of between 4 dB - 1.2 dB (60.4%-23.6%) and between 4.1 dB - 1.2 dB (60.8%-23.6%) for the AN10858 and FPD2000AS RF power amplifiers respectively, when compared to an ACE, TR, OFDM

Table 5.2: Decision metric performance improvement obtained when using OM-OFDM at a BER of 10^{-4}

Method	**Amplifiers**	
	AN10858	**FPD**2000**AS**
OFDM	2.8 dB (47.6%)	2.2 dB (39.8%)
Clipping	4.0 dB (60.4%)	4.1 dB (60.8%)
ACE	1.2 dB (23.6%)	1.2 dB (23.6%)
TR	2.7 dB (45.3%)	2.0 dB (36.8%)

and a clipped OFDM transmissions. Furthermore, at the optimum operating point of an OM-OFDM transmission (10 dB), the FPD2000AS and AN10858 RF power amplifiers produce decision metric results of 36.32 dB and 34.38 dB respectively. This comparison indicates that the AN10858 amplifier offers a 1.94 dB improvement over the FPD2000AS amplifier, thus making it a better amplifier for this particular application. This result was intuitively expected, since the AN10858 RF power amplifier has been specifically designed for this current application (8k mode of the DVB - T standard).

5.5 COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION PERFORMANCE ANALYSIS

Based on the optimum operating points obtained from the decision metric in the previous section, the complementary cumulative distribution function, depicted in Fig. 5.5, was used to compare the PAPR characteristics of an OM-OFDM, OFDM, clipped OFDM, TR and ACE transmission. At these optimum operating points OM-OFDM is shown to offer a PAPR reduction of 2.27 dB, 2.56 dB, 2.75 dB and 3.19 dB (at a CCDF of 10^{-1}) when compared to a clipped OFDM, ACE, TR and OFDM transmission respectively. Although the clipping

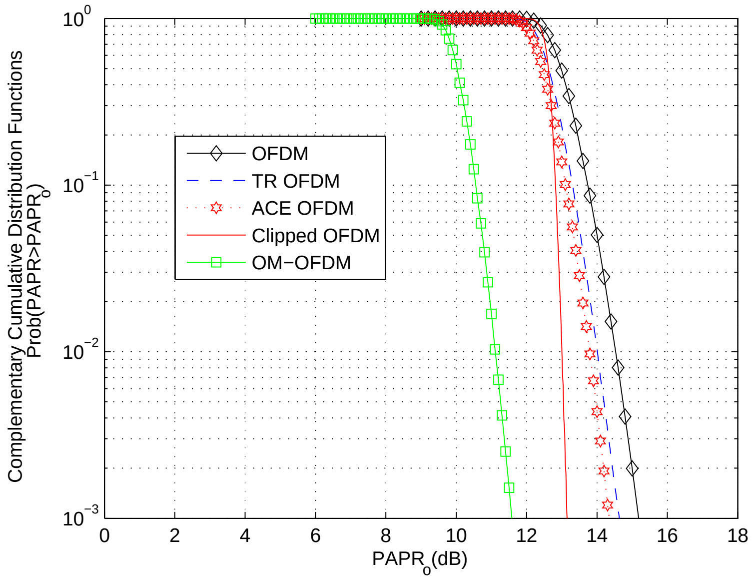


Figure 5.5: Complementary cumulative distribution functions of an OM-OFDM, clipped OFDM, ACE, TR and OFDM transmissions for a 64-QAM constellation.

method offers attractive CCDF results, the subsequent BER characteristics are not attractive. From these comparisons, it is noted that OM-OFDM offers a significant PAPR reduction when compared to the various methods.

5.6 CONCLUSIONS

In this chapter, the proposed OM-OFDM method was compared to OFDM, as well as existing PAPR reduction methods. A BER comparison between OM-OFDM and OFDM, at a PAPR value of 13 dB, indicates that both methods offer similar BER characteristics for frequency selective fading channel conditions. The OM-OFDM method is also able to control the PAPR of a transmission accurately for a targeted BER.

When utilising the decision metric, OM-OFDM is shown to offer a net power performance gain of between 4 dB - 1.2 dB (60.4%-23.6%) and 4.1 dB - 1.2 dB (60.8%-23.6%), at a BER of 10^{-4}, for a AN10858 and FPD2000AS RF power amplifier respectively, when compared to clipped OFDM, OFDM, TR and ACE transmissions, in a frequency selective fading channel. These results can be further summarised, as depicted in Fig. 5.6. In Fig. 5.6, the normalised decision metric results for an AN10858 and a FPD2000AS RF power amplifier, when comparing clipped OFDM, OFDM, OM-OFDM, TR and ACE transmissions, in frequency selective fading channel is presented. This graphically illustration, depicted in Fig. 5.6, indicates the significant power performance offered by OM-OFDM when compared to various other methods. By utilising a complementary cumulative distribution function, the OM-OFDM method is further shown to offer a PAPR reduction of between 3.2 dB - 2.3 dB (at a CCDF of 10^{-1}) when compared to an OFDM, TR, clipped and ACE OFDM transmissions. Hence, the proposed OM-OFDM method has offered performance improvements when compared to simple (clipping) as well as more well-established (ACE and TR) iterative (30-60 iterations) methods.

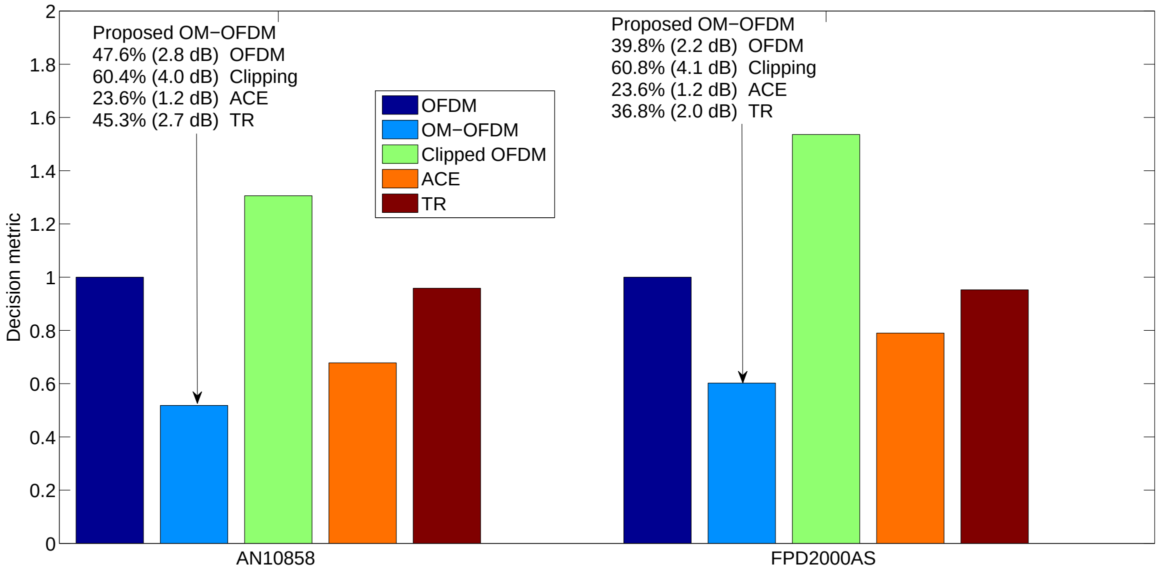


Figure 5.6: Summarised normalised decision metric performance results for a 64-QAM constellation at a BER of 10^{-4} for AN10858 and FPD2000AS RF power amplifiers under frequency selective fading conditions.